08/493,480 ~~Cont~~ patent of US Pat. #6,366,771

493480

Extended Working Range Dataform Reader With Externally Mounted Illumination Module

Cross Reference to Related Applications

This application is a continuation-in-part of copending application serial no. 08/332,592, filed October 31, 1994 and application serial no. 08/280,489, filed July 26, 1994.

The invention relates to dataform readers and methods for reading dataforms including barcodes, such as 1D and 2D codes, and other dataforms such as matrix codes. More particularly, the invention relates to dataform readers and methods which achieve high resolution imaging of the dataforms with an improved optical system having an increased working range, and an improved illumination system associated therewith.

Background of Dataforms

The application and use of bar codes and matrix codes are well known and growing. Bar codes and matrix codes are forms of "dataforms", which for present purposes are defined to include all arrangements whereby data is fixed in some form of machine readable copy. Thus, dataforms include one and two dimensional bar codes (e.g. UPC, C128, PDF417, etc.), matrix codes (e.g. Maxicode, Data Matrix, Code 1, etc.) and graphic codes, as well as words and numbers and other symbols, which may be printed or etched on paper, plastic cards and metallic and other items. Dataforms may be printed in invisible ink, magnetically recorded via magnetic stripes or magnetic ink fonts, electromagnetically recorded via RF tags, engraved, stamped, tattooed (on skin), formed by ion doping (for semiconductor wafers) or biochemical binding, etc.

In the utilization of dataforms, data originally encoded is recovered for further use in a variety of ways. For example, a printed bar code may be optically scanned to derive reflectance values which are digitized, stored in buffer memory and subsequently decoded to recover the data encoded in the bar code. Regardless of the particular type of dataform, an image is typically acquired and stored as pixel values for further processing. An image of a bar

code or matrix code existing as a graphic image can be acquired by use of a CCD reader, a laser scanner or other suitable device which is capable of distinguishing between different reflective values of light reflected data cells and synchronizing the data cell format for a particular dataform. Thus, for example, a bar code typically comprises black or dark colored bar type elements printed on a white or light colored background area, with white or light colored spaces between the elements of the bar code. The spaces are typically the same color as the background area, but may be of a different light color in this example. In other examples the elements of a bar code or matrix code are white or light colored and are defined by black or darker colored spaces and background area.

In other applications, such as laser engraving on silicon wafers, illumination may result in a dark on light relationship in one orientation and a light on dark relationship in a different orientation, In addition to pixel values representing reflective values of light ("light" being defined as encompassing the entire electromagnetic spectrum for present purposes), in other arrangements pixel values representative of reflective values may be based upon reflection of sound waves or other mediums from a dataform of an appropriate configuration. In any arrangement in which a dataform is arranged to be read on the basis of reflective values, such reflective values may typically be stored as pixel values in an image buffer memory or other storage medium in bit map or other form which, while representative of pixel values for an image, may utilize any appropriate data storage format.

Background of Dataform Reader

Current art portable terminals with integrated laser barcode scanners or CCD barcode readers are not well suited for reading two dimensional dataforms. Laser barcode readers operate by projecting a narrow laser beam of light which forms an intensely illuminated spot on the barcode. Oscillating mirrors continually redirect the laser beam so that the spot moves in a sweeping pattern or a raster pattern. Generally a sweeping pattern refers to

oscillation of the beam along the horizontal axis without any vertical oscillation. A raster pattern refers to a rapid oscillation along the horizontal axis and a slower oscillation along the vertical axis so that raster pattern appears to be a sweeping pattern moving up and down. A photodetector collects illumination from the entire target area. When the moving, or flying spot is incident on a highly reflective portion of the barcode, such as a white background, light reflected from the spot is incident on the photosensor. When the flying spot is incident on a less reflective portion of the barcode, such as a black bar, less light is reflected towards the photodetector.

A laser scanner does not have an internal synchronization mechanism. The laser scanner calculates the laser spot's relative horizontal position based on known self-synchronizing patterns in the 1D barcode. This can be referred to as a code self-synchronized system. A raster pattern laser scanner can read 2D stacked barcode such as PDF-417 because PDF-417 has particular row indicator patterns which are recognizable and used by the scanner for vertical synchronization. This system has vary little rotation angle tolerance, because the scanner can not recognize a row indicator pattern or other codeword pattern unless the spot sweeps across the entire pattern.

A laser scanner can not read 2D matrix codes such as the Maxicode and the Datamatrix because such codes do not have row indicator patterns for vertical synchronization.

In addition to laser scanners, there exists 1D CCD array barcode readers. The CCD reader operates by imaging a long and thin target area onto a one-dimensional photodetector array rather than scanning a spot of illumination across the barcode symbol. If the reader is positioned relative to a 1D barcode so that the imaged target area falls relatively across the barcode. The barcode can then be decoded based on the run-length sequences of grayscale values derived from the pixels on which each bar and space of the code is imaged. Similar to the laser scanner, the 1D CCD has no vertical

synchronization and must rely on row indicator patterns for vertical synchronization.

More recently, the CCD reader concept has been extended to two-dimensional CCD readers such as the TEC contact reader made by Tokyo Electric Company. A two dimensional CCD reader images an area onto a two-dimensional array of photodetectors. Such a device is capably of reading matrix codes because the 2-dimensional pixel array provides both horizontal and vertical synchronization. However, this reader has a vary small working range (less than 0.5 inches) and field of view (less than 1.2 inches by 1 inch) due to limitations in the illumination system and the optical imaging system.

Current illumination configurations are generally characterized by a plurality of discrete LED assemblies, including the LED and an acrylic optic encasing the LED, assembled on a printed circuit board within the reader housing. The housing has an aperture through which illumination from the LEDs is projected towards the target area and reflected illumination is collected by the focusing optics of the reader. Typically a window is located in the aperture to prevent dust and moisture from entering the interior of the housing. However this can cause an illumination intensity loss when projected through the window and internal reflection caused by illumination reflected form the interior window surface towards the photosensor. The current illumination configurations do not provide either adequate or uniform illumination on a distant target to provide an image with decodeable contrast. Other illumination configurations use a frosted or holographic diffuser over high intensity illuminators to achieve illumination uniformity will cause a higher power consumption due to the low transmission efficiency of the diffuser. Power consumption must be controlled in a battery powered product.

The current CCD readers also have a limited working range such that if the reader is too close or too far from the code, the image produced by the imaging system will be blurred, and proper resolution for decoding cannot be obtained. A small depth of focus is generally unacceptable for a portable

product because it requires higher operator precision in locating the reader over the barcode.

Attempts have been made to provide auto-focusing to gain working range. Auto-focusing techniques include moving parts which are susceptible to damage, particularly if used in portable dataform readers which can be easily dropped. Auto-focusing techniques are also generally slow in response time, which has been found to be unacceptable in the environments in which such dataform readers are used. Auto-focusing systems will further add significantly to the cost of the reader, making it prohibitive for general use. An alternative attempt to improve the depth of focus is sacrifice resolution, that is image a smaller field of view, thereby a barcode, although blurred if out of focus, can still be decoded because each data cell is imaged onto more pixels. However, this configuration cannot read a large barcode due to the small field of view.

Therefore there is a need to have a non-contact 2D imaging based dataform reader which can read 1D barcodes, 2D stacked barcodes and matrix codes omni-directionally. Furthermore, there is a need to have such dataform reader achieve an extended working range without using an auto-focusing system and without sacrificing the optical resolution. Yet another need is to have a externally mounted illumination module to provide highly uniform and energy efficient extended range illumination without internal reflection illumination noise.

Summary of the Invention

In accordance with this invention a portable dataform reader is provided that includes an illumination module secured to the front surface of the reader housing. The illumination module is secured to the front of the dataform reader to avoid the illumination loss problem and the internal reflection illumination noise problem associated with placing the illumination source behind a window within the reader housing.

The illumination module includes a printed circuit board assembly, a plurality of surface mount LEDs secured to the front side of a printed circuit

board, and a lens array. The board is bonded into a cavity in the backside of a durable acrylic lens array. The lens array operates to direct uniform and intense illumination towards a target area in front of the reader.

Within the forward end of the reader housing is a reader module. The reader module includes a board camera and an optic assembly focusing an image of the target area onto a photosensor array. The optic assembly provides for good contrast modulation within an extended working range.

In the preferred embodiment, the illumination module has an aperture in the center and the reader module is positioned to gather light reflected from the target area through the aperture. This configuration assures illumination directed from the lens array of the reader module is aligned with the field of view of the reader module.

Furthermore, because the reader of this invention is intended for portable use, this invention provides for a reader with a spread spectrum radio which operates to couple the reader with a remote host computer or the other portable dataform reader through an IEEE 802.11 compatible network. The spread spectrum radio can be used to transmit decoded dataform data, photographic image data in a compressed format, or compressed data files representing voice messages.

Also in accordance with this invention, the dataform reader includes user interface devices such as a keyboard, display, touch panel, microphone and speaker which operate with various circuits to improve the functionality of the reader.

For a better understanding of the invention, together with other and further objects, reference is made to the accompanying drawings and the scope of the invention will be pointed out in the accompanying claims.

Brief Description of the Drawings

Figure 1 shows a perspective view of a hand held portable dataform reader according to this invention.

Figure 2 shows a side view of a hand held portable dataform reader according to this invention.

Figure 3 shows a front view of the housing of the portable dataform reader according to this invention.

Figure 4 shows a perspective view of an alternative hand held portable dataform reader according to this invention.

Figure 5 shows a top view of the portable dataform reader of figure 4.

Figure 6 shows a front view of the housing for the portable data terminal of figure 4.

Figure 7 shows hand held operation of the portable dataform reader of figure 4.

Figure 8 shows an exploded perspective view of the illumination module of this invention.

Figure 9 shows a side cross sectional view of the illumination module of this invention.

Figure 10 shows assembly of the illumination module to the front of a dataform reader housing in accordance with this invention.

Figure 11 shows assembly of the illumination module to the front of an alternative embodiment of a dataform reader housing in accordance with this invention.

Figure 12 shows a cut away side view of the dataform reader of figure 1.

Figure 13 shows a cut away side view of the dataform reader of figure 4.

Figure 14 shows a top cross sectional view of the reader module according to this invention.

Figure 15 shows a MTF plot for a preferred embodiment of the optic assembly according to this invention.

Figure 16 shows a block diagram of the voice mail system according to the present invention.

Figure 17 shows a wireless headset in accordance with this invention.

Detailed Description

An embodiment of the portable dataform reader of this invention can have several housing configurations, two of which are generally shown in figures 1-6. Like numerals are used to identify similar parts, the housing shown in figures 1-3 is generally a gun shaped reader **10** with a housing **12**, forming an upper enclosure, and a handle portion **14** extending below the upper enclosure. The housing is constructed of a suitable impact resistant plastic that provides both durability and light weight. A trigger switch **16** is appropriately mounted and used to provide a signal to initiate a dataform reading session. A plurality of key switches **22** and a display screen **32** with an overlaying touch panel **44** are visible on the upper surface. An illumination module **28** is secured to the forward end of the housing **18** so that the noise effects and illumination loss associated with placing illuminators within the housing and behind a window are eliminated. The forward end of the housing **18** is shown in figure 3 without the illuminator module **28**. A generally circular shaped aperture **17** is formed in the forward end **18** so that a dataform positioned to the front of the reader may be read by a reader module positioned in the forward end of the upper enclosure. The housing also includes four holes **19** for securing the illuminator module to the front of the housing **18** with screws. The terminal **10** shown in figures 4-6 is generally a palm sized terminal configured to be held in the palm of the operators hand as shown in figure 7. A plurality of key switches on the upper surface **22** are positioned to be operated by the same hand holding the terminal. Also on the upper surface is a display screen **32** with an overlaying touchpanel **44**. The housing **12** is constructed of a suitable impact resistant plastic for both durability and light weight. A trigger switch **16**, to initiate a dataform reading session is located at the center of the upper surface to enable activation by the operator's thumb. The illumination module **28** is secured to the forward end of the housing **18**. The forward end **18**, shown without the illumination module **28** in figure 6, includes a generally

circular shaped aperture **17** so that a dataform positioned in the front of the terminal **20** may be read by a reader module positioned in the forward end of the terminal.

Referring to figure 8, which is a perspective explosion view of the illumination module **28**, it can be seen that module **28** includes a lens array **24** and a printed circuit board assembly **40**. The printed circuit board assembly **40** includes a plurality of surface mount LEDs **46** secured to a printed circuit board **54**. For example, a suitable surface mount LED is produced by the Marktech Corporation of Latham, NY, as Part No. MTSM735K-UR or MTSM745KA-UR. Each provides illuminosity of 285 mcd. Printed circuit board **54** includes printed conductors and power lead **72** operative for supplying power to the LEDs **46**. The lens array **24** includes a plurality of exposure illuminator lens elements **30** and two targeting lens elements **34**, all of which are positioned in front of an LED **46**. The exposure illuminator lens elements **30** direct illumination uniformly across the target areas. The targeting lens elements **34** project two pencils of targeting illumination **107**, forming hot spots, into the target area at angles corresponding to the reader module field of view **68** (discussed later). The hot spots are visible to the operator and facilitate positioning of the portable dataform hand held reader so that the target dataform is within the field of view of the reader module.

The lens array **24** forms the front surface of the illumination module protecting the printed circuit board assembly **40** from physical impact as well as from dirt, moisture and other harmful elements found in the environment. Therefore, the lens array **24** is preferably molded of an impact resistant acrylic or other suitable material that has a high illumination transmittivity and durability necessary for the environment in which a portable hand held dataform reader is operated. To further protect the printed circuit board assembly **40** from harmful elements in the environment, a conformal coating is applied to the board assembly **40** and the assembly is bonded into a cavity in the back of the lens array **24** with a cyanoacrylate, UV curing or structural adhesive.

Referring to figure 9 which shows a cross section of the assembled illumination module **28**, it can be seen that each exposure lens cell **30** includes an inner lens surface **42** and a focal point **80**. By locating the LED between the focal point **80** and the interior surface **42**, the lens cell acts as a light directing element rather than an imaging element thereby avoiding hot spots in the target area and providing a highly uniform illumination.

Figure 10 shows how the illumination module **28** is secured to the front of the dataform reader **18**. The illumination module **28** has a generally circular aperture **36**. The illumination module is positioned to the front of the reader such that aperture **36** aligns with aperture **17** in the front of the reader housing **18** so that the reader module **26** within the reader housing **12** can receive reflected illumination from the target area through aperture **36**.

Four screws **51** are inserted into the screw holes **38** in the illumination module and thread into co-axially aligned holes **19** in the front of the housing to secure the illumination module to the front of the housing. A power and control lead **72** extends from the back of the printed circuit board **54** and through an aperture **74** in the front of the reader housing **18**.

Figure 11 shows the reader module **28** mounted to the front of an alternative embodiment of the reader housing **12**. The reader housing includes a shroud **76** around the periphery of front surface **18** which operates to protect the reader module from side impact. The shroud **76** could be integrally molded into the housing **12** or could be a separate shroud secured to front surface **18** and formed of a pliable energy absorbing material such as Sorbathane™ available from Sorbathane Corporation of Kent Ohio.

Referring to figures 12 and 13, which show a cut away side view of the reader of figures 1-6, it can be seen that a reader module **26** is positioned inside of the reader housing immediately behind the front surface **18**. The camera housing **64** projects through the aperture **17** in the housing and aperture **36** in the illumination module. A seal (not shown) may be placed around the camera housing nose **64** to create a tight seal between the camera

housing and the reader housing **12** to prevent dirt and moisture from entering the interior of the reader housing through the aperture **17**.

Figure 14 shows a top view of the reader module **26**. The module includes a board camera assembly (shown as a three board assembly) **62** with a two-dimensional array of photodetectors **60**. The reader module **26** also includes an optic assembly **58** for focusing an image of the target area onto the two dimensional array of photosensors **60**. A camera housing **64** shrouds ambient light from the photosensor array **60** and positions the optic assembly **58**.

The optic assembly **58** must provide a large working range such that a dataform in the target area or object field **66** must be clearly focused throughout the entire range between a near field distance of **S1** and a far field distance of **S2**. The optic must also have a field of view **68** which is wide enough to image large dataforms at the far field **S2** and still provide a large image of a small dataform located at the near field **S1**. In the preferred embodiment the optical assembly **58** has a working range from about 2.5" to at least 8.5" from the front surface of the optical assembly **86**, with best focus distance being at 5.5". The preferred field of view corresponds to a target surface of 5 inches long by 3.75 inches wide at a distance of 8.5" from lens surface **86**. To achieve the above stated working range, the optical assembly **58** shall be designed to have a through focus MTF (modulation transfer function) of at least 40% at 50 cycles at the best focus position and at least 15% at a +-0.5mm focus shift from the best focus. Referring to figure 15, the preferred optical assembly **58** for this invention has a through focus MTF of 60% at 50 cycles at the best focus position and 20% at +-0.5mm focus shift from the best focus.

Referring again to figure 14, one of the preferred embodiments of the optic assembly includes two symmetrical lenses **82** and **84** arranged adjacent to another. The symmetrical system is advantageous in that only one lens configuration needs to be fabricated to provide the lens assembly. For the lens

82, at least one of the surfaces **86** or **88** is formed with an aspherical surface providing correction of spherical aberration as well as correction for other aberrations including field curvature, astigmatism and distortion. In the preferred embodiment surface **86** has a magnitude and shape defined as an even asphere having a radius of curvature of 1.5298mm, a conic constant of -0.019890, a 6th order aspheric deformation coefficient of 0.0096mm, an 8th order coefficient of
-0.0057, and a 10th order coefficient of 0.0023. The surface **88** is a spherical surface with a radius of curvature of 1.6004mm. An aperture **90** is positioned between the lenses **82** and **84** as shown and provides the optical assembly an F#13.

The board camera assembly **62** includes a CCD sensor array **60**. The output signal from sensor array **60** is a non-gain corrected raw video voltage signal. The voltage, at particular time increments, represents the accumulated charge on individual pixels. The board camera assembly **62** includes circuitry for generating a clock signal operative for driving the readout of the sensor array **60**, exposure control circuitry for adjusting the exposure time for each field, gain control circuitry operative adjusting the gain of the raw video signal and other circuitry operative for generating a composite video signal from the raw video signal.

Typical board cameras only have two operational states, "off" and "read-out". The off state corresponds to a complete power shut down of the board camera. The "read-out" state corresponds to continuous generation of a video signal. Such a device is not practical in a portable dataform reader because it has a power up latency time, that is the period of time required to generate a stable video signal when transitioning from the "off" state to the "read-out" state of over 1 second. Because a portable dataform reader must provide a sub-second user response time, the board camera must remain in the "read-out" state continually. However, when in the "read-out" state, the device consumes too much power and would drain the batteries of a typical portable

product within an hour. A preferred board camera **62** of this invention has three operational states, "off", "ready", and "read-out". The "off" state and the readout state correspond to equivalent states in a typical board camera. However, in the "ready" state, power remains on to those circuits that cause the long power up latency and power is not applied to circuits that have a shorter latency. Particularly, power is not applied to circuitry that causes the clocking signal for sensor array readout.

Again referring to figures 12 and 13, it can be seen that the interior of the housing **12** includes a plurality of printed circuit boards including decoder board **56** and control board **31**. When in the readout state, the video signal from the board camera is transferred to the decoder board **56**. The decoder board **56** includes image processing circuitry operative to decode the dataform in the image area and transfer the decoded results to the control board **31**, preferably through a serial interface. An appropriate decoder system is described in US Patent Application __________ filed May 17, 1995, and US Patent Application __________ filed May 31, 1995, the contents of both applications are hereby incorporated by reference. Other decoder systems known in the art are also contemplated by this invention.

Decoder board **56** also controls the dataform reading sessions by controlling the operational states of the board camera and supplying exposure and targeting power to the illumination module on a mutually exclusive basis. The control board **31** or the trigger switch **16** can send a signal to the decoder board **56** to initiate a reading session.

Because the dataform reader module **26** is capable of capturing an image of the target area, the device, in addition to capturing the image of a dataform for the decoding process, can be used to photograph an object in the target area. For example, an operator can use the reader module to photograph a damaged product and also capture an image of a dataform associated with the damaged product. When a photograph image is captured, the decoder board will transfer a digital image representation, such as a bit

map, of the image to the control board **31** instead of decoding (processing) the image.

The control board **31** includes a serial output port coupled to a connector on the housing operative to transfer the decoded data or image data to a remote terminal through a cable connection (not shown). The connector may be a traditional pin connector to which a mating connector is secured. Alternatively, as shown in figure 1, the connector may be conductive contact surfaces **11** on the exterior of the housing **12** which align with mating contact surfaces when the dataform reader is placed in a docking station.

Because the dataform reader of this invention is intended for portable use, a wired connection to a host computer is impractical in many situations. Therefore, the reader includes a spread spectrum radio board **33** providing a wireless link between the control board **31** and a remote host computer. External antenna **46** as shown in figure 12, or internal antenna **47** as shown in figure 13, operate to improve reception. The spread spectrum board **33** includes digital and analog circuitry for transmitting and receiving data in a wireless network such as an IEEE 802.11 compatible direct sequence spread spectrum or frequency hopping spread spectrum network.

Because the spread spectrum radio, the dataform reader module and the illumination module all draw significant current from a power cell **48**, the radio should not operate during a dataform reading session and a reading session should not start during radio communication to limit peak current draw. Therefore, the radio and the circuitry controlling the dataform reading session provide blocking signals to each other to assure that power is not being drawn simultaneously. The blocking signal from the radio to the dataform reading circuitry will prevent the initiation of a reading session. The session will be delayed until the signal desists. The blocking signal from the dataform reading circuitry to the radio will prevent the radio from sending or receiving data packets. Therefore, the network transmission protocol must be such that the radio in the portable dataform reader has complete control over when to

transmit a packet and when it can receive a data packet. One such network protocol is the reverse poll protocol as described in US Patent 5,276,680 and assigned to Telesystems S/W Inc., the entire contents of which is hereby incorporated by reference.

In the reverse poll protocol network, the portable device radio may transmit data packets to a network access point at any time, subject to the carrier frequency being free. However, the access point can only send a packet to the portable device within a time window following receipt of a packet from the portable device. To assure that the access point has enough opportunities to transmit data to the portable, the portable will periodically send packets even though they contain no significant data.

While the spread spectrum radio is effective for transmitting the decoded contents of a dataform, the radio's limited bandwidth makes it impractical for transmitting an entire un-compressed image. An image compression algorithm useful to reduce the size of a digital image file is the two-dimensional wavelet transform as described in *A 64kb/s Video Code Using the 2-D Wavelet Transform* by A.S. Lewis and G. Knowles, published in IEEE Computer Society Press, Order Number 2202. For example, the HARC wavelet transform system, available from Houston Advance Research Center in Houston Texas, can be used to compress the photographic image before it is transmitted with an image compression ratio of up to 400:1.

Because the dataform reader is intended for portable use, it is quite possible that an operator working at a remote location of the facility may need to request supervisory instructions while capturing dataforms. Therefore, the dataform reader of this invention includes a voice mail processing board **37** so that the operator may verbally communicate with others through the spread spectrum network. Referring to figure 16, a block diagram of the voice mail circuitry is shown which may be embodied in a microprocessor system or voice mail processing board **37** and control board **31**. A voice message is input through an audio input circuit **92** which can include an internal microphone or

a port for connection to an external microphone which will be discussed in more detail later. A digitizer/compression module **94** will create a digital data file representative of the audio input.

Prior to transmitting the message, the message control unit **98** will prompt the operator to identify the addressee. The prompt may take the form of an audible signal to the operator through the audio output circuit **100** (discussed later), or a display screen message. destinatn address

In a time window following the prompt, the operator must identify the addressee. This can be done through the keyboard **22** or touch panel **44** (as shown in figures 1-6). Alternatively, the addressee may be identified by audio input. In this embodiment, voice recognition circuitry **102** will operate to convert the audio signal to a digital address. destina

The message control unit **98** will add the address to the message and relay the message to the spread spectrum transceiver for broadcast to the addressee. It should be appreciated that the voice mail system could require operator identification of the addressee before or after input of the message.

The message control unit **98** operates to receive data files representative of incoming voice mail messages and stores such messages in memory **96**. Upon receipt of an incoming message, the control unit **98** notifies the operator of receipt through the audio output circuit **100**, the display screen or a dedicated illuminator.

Upon an operator prompt to output the voice mail message, the control unit **98** will retrieve the data file from memory. A decompression module will convert the data file to an analog signal and audio output circuitry, which may include a speaker or a port for a remote speaker or headset will output the message. The operator prompt to output the message may be through the keyboard **22**, touch panel **44** or the voice input circuit **92**.

After output of the message, the voice mail unit of this invention can optionally store the message for later playback or erase the message. In conjunction with storage or erasure, the message may be forwarded or

responded to. The control unit will prompt the operator to input the various permutations of these options. If the message is stored, the digital data file will remain in memory **96**. If forwarded, the data file, or a copy, will be appropriately addressed and transmitted to the spread radio **33**.

If the respond option is selected, the identity of the address of the response message is known and the control unity **98** prompts the operator to input a response message. The digital data file representative thereof is sent by the spread radio.

Referring back to figure 5, the speaker **50** and the microphone **52** are preferably positioned so that the reader may be held along the side of the operators face like a telephone set for communication. Referring to figure 17, the speaker and microphone are embodied in a wireless headset. The headset includes a headband **115** for holding the device on an operators head, a speaker **117** positioned near the operators ear and a microphone **119** positioned near the operators mouth. A micro-radio module and power source are located in a housing **121** attached to the headset.

Referring again figure 12, the reader includes a similar micro-radio embodied on board **35** for transceiving audio signals with the headset. The micro-radio operates on a narrow band modulation scheme wherein the band is aligned in a null of the frequency spectrum of the spread spectrum radio.

In addition to operating in conjunction with a wireless headset, the micro-radio can function as a wireless peripheral port so that the operator may print a dataform label without physically connecting the dataform reader to a printer. Printers or other peripheral devices with similar micro radio boards may be placed throughout the installation in which the terminal is operated. When an operator approaches the peripheral device with the terminal, a hand shake sequence is initiated and a wireless link is established. Data from the terminal may be printed out on the peripheral device.

Because the dataform reader of this invention is intended for portable use it is desirable that the power source **48** provide for operation over an

extended period of time without requiring recharging. Although the power source **48** could be any rechargeable cell, the preferable power source is a plurality of Lithium Polymer flexible battery cells. Each flexible sheet is about .002" (2mils) thick and appears to be a sheet of plastic. To construct such a cell, Li Mn_2 O_4 is used as the cathode and carbon as the anode. Such a cell is available from Bellcore of Red Bank New Jersey. One advantage of the lithium polymer cells is that the flexible sheet form factor is such that the cells may be folded and placed in areas of the housing which are of inadequate space for traditional cylindrical cells. In figure 13, the polymer sheet cells **48** are advantageously shown along the surface of the housing interior wherein the polymer cells also function to reduce unwanted EMS. In addition to the form factor and EMS advantages, the lithium polymer cells are rechargeable and provide about 3 times the energy density as the NiCad cells and do not suffer the NiCad crystallization that produces the degenerative memory effect.

While the description has described the currently preferred embodiments of the invention, those skilled in the art will recognize that other modifications may be made without departing from the invention and it is intended to claim all modifications and variations as fall within the scope of the invention.